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Ice-Worms
(Oligochaeta: Enchytraeidae)
from Western British Columbia

Michael J. Tynen

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Summary

Ice-worms, *Mesenchytraeus solifugus* (Emery), from the two British Columbia glaciers are compared with previous descriptions of worms from Alaska and the state of Washington. It is concluded that the Canadian worms resemble the Alaskan worms less closely than they resemble those from the state of Washington.

Résumé

Les vers de glaciers, *Mesenchytraeus solifugus* (Emery), qui se trouvent dans les deux glaciers de la Colombie Britannique, sont comparés à ceux de l'Alaska et de l'état de Washington, antérieurement décrits. L'étude conclut que l'espèce canadienne se rapproche davantage de celle de l'état de Washington.

Biographical Note

Michael J. Tynen received his Ph.D from the University of Wales in 1966 for work on the littoral Enchytraeidae (Oligochaeta) of Anglesey, North Wales. Until the end of 1967, he worked on the Pacific oyster with the Fisheries Research Board of Canada at Nanaimo, British Columbia. He then joined the Department of Zoology, University of Alberta, and worked there for over two years as a Post-Doctoral Fellow and Sessional Lecturer. During this time, he worked on the systematics and biogeography of the ice-worm, making a field study which confirmed the absence of this species from the glaciers of the western interior.

Dr. Tynen returned to Great Britain in 1970 and now teaches at Fareham Technical College, Hampshire.

Acknowledgements

My trip to the Cliffe Glacier was financed by the National Museum of Natural Sciences and was made with Mr. John Cowlin and a group of the Vancouver Island Mountain Ramblers. I am most grateful for their help and patience with a completely inexperienced outdoorsman which made the venture possible.

The specimens from the Le Duc Glacier were collected by Mr. Ted Groves and forwarded to me by the late Dr. G. Clifford Carl, Director of the British Columbia Provincial Museum at that time.

I am especially grateful to Mr. John Bagshaw and Mr. Rick Forchuk for their help in sectioning the material.

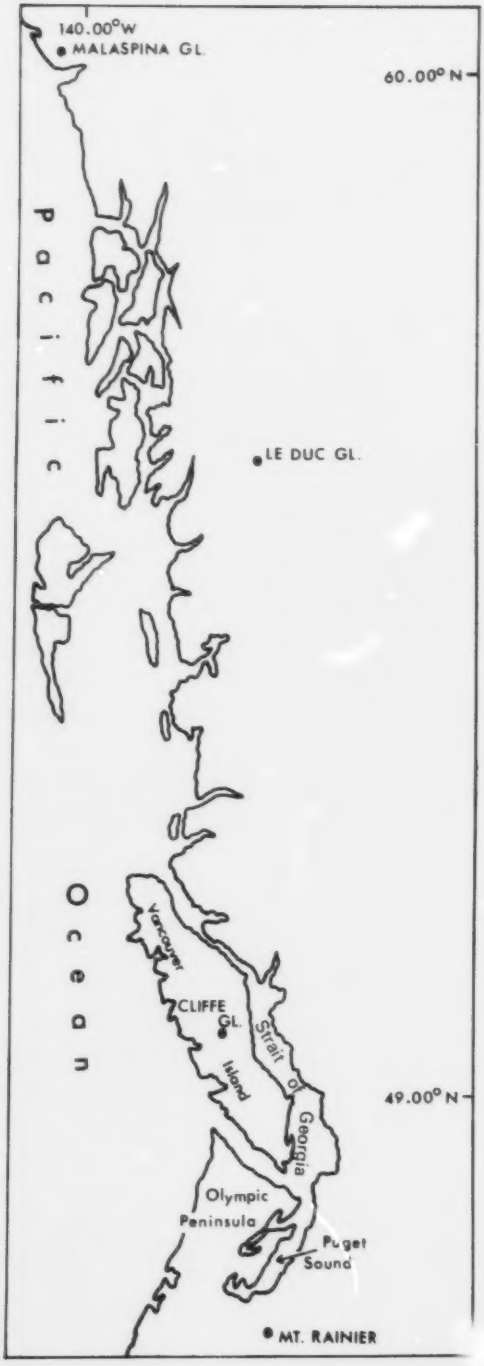

Figure 1 The north-west coast of North America, showing the position of some of the glaciers mentioned in the text.

Introduction

The presence of worms on the glaciers of western North America was first noted in 1886 by G. F. Wright, a geologist working on the Muir Glacier, Alaska (Wright 1887). Later, Emery (1898, 1900) described specimens from the Malaspina Glacier, Alaska (60°00'N, 140°30'W) and gave them the name *Melanenchytraeus solifugus*, creating a new genus of the family Enchytraeidae to accommodate them. Moore (1899), after examining some further specimens from the Malaspina Glacier, transferred them to the existing genus *Mesenchytraeus*. *Mesenchytraeus solifugus* (Emery 1898) is the currently valid designation.

Eisen (1904) briefly described specimens from the Muir and La Perouse Glaciers, Alaska, and generally concurred with Moore's (1899) description. After Eisen's account, the worms were reported spasmodically in various localities from Alaska to the state of Washington. The only other detailed description was by Welch (1916) of worms collected on the snow fields of Mt. Rainier, Washington (46°52'N, 121°45'W). These specimens differed in several respects from the Alaskan forms and Welch gave them the status of a new variety or subspecies—*Mesenchytraeus solifugus* var. *rainierensis*.

Ice-worms have not been found in the Rockies or other interior situations, and Mt. Rainier seems to be their southern limit (Tynen 1970).

The presence of a distinct form on Mt. Rainier may be the first indication of a whole series of geographic races, each evolving in isolation on the various glaciers of the Pacific Northwest. It was, therefore, with considerable interest that I examined specimens of ice-worms from the Le Duc Glacier near Stewart, B.C. (56°00'N, 129°50'W), and from the Cliffe Glacier in central Vancouver Island (49°31'N, 125°24'W) (Fig. 1).

In this paper, I propose to compare the British Columbia specimens with previous descriptions, paying particular attention to the taxonomically significant characters and especially those whereby Welch (1916) justified the setting up of a new subspecies to accommodate the Mt. Rainier specimens.

Materials and Methods

The specimens from the Le Duc Glacier were collected by Ted Groves of the provincial Department of Mines in August 1967 and forwarded to me via the British Columbia Provincial Museum. When I received the specimens, they were in formalin. Four specimens were sectioned transversely, five longitudinally. All were stained with Erlichs haematoxylin and eosin. The remainder were returned to the British Columbia Provincial Museum, Victoria.

I collected further specimens on the Cliffe Glacier in July 1968 and these were fixed in the field in a mixture of 30 per cent water, 30 per cent ethanol, 20 per cent formalin, 10 per cent glycerine and 10 per cent acetic acid. Twenty-four hours later, the worms were transferred for storage to the same mixture minus the acetic acid. These specimens sectioned more satisfactorily than the Le Duc Glacier material. One was cut transversely, four longitudinally; all were stained with haematoxylin and eosin. Sections and whole specimens are lodged with the National Museums of Canada (catalogue numbers 3401, 3402).

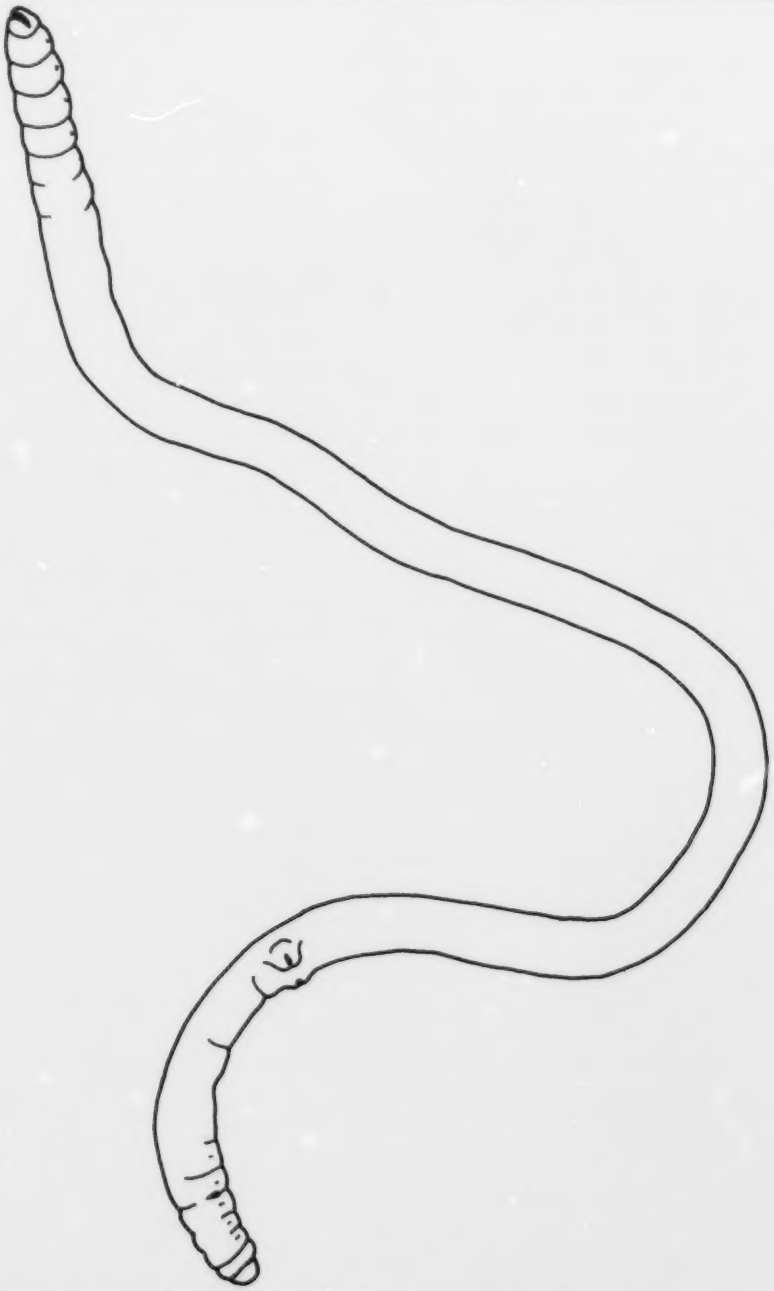

Figure 2 *Mesenchytraeus solifugus*: whole worm.

Synonomy

Melanenchytraeus solifugus Emery 1898
Mesenchytraeus solifugus (Emery 1898), Moore 1899
Mesenchytraeus solifugus rainierensis Welch 1916

Diagnosis

(Based on all available data. See Table 1 for differences between populations.) Length, 12-20 mm. Width, 0.25-0.42 mm. Segments, 43-60. Colour of live worms in daylight, black. Head pore at tip of prostomium. Dorsal pores absent.

Setae: dorsal preclitellar, 2,3; dorsal postclitellar, 1,2; ventral preclitellar, 2,3,4,5,6; ventral postclitellar, 2,3,4,5.

Clitellum: none discernible.

Brain incised anteriorly, straight or slightly convex posteriorly; almost square.

Three pairs of septal glands, none joined dorsally. Second and third pairs (at 5/6 and 6/7) are largest and have forward extensions of the ventral portions.

Dorsal vessel arises in segments 12-14.

Nephridium with long, slender anteseptale; efferent duct arises posteroventrally.

Sperm funnels 2-3 times longer than wide, tapering slightly towards the duct. Sperm duct usually lies within egg sac, often extending backwards through many segments to the bottom of the egg sac before doubling back to the atrium. Sperm sacs usually paired, usually lying in egg sac of same side, often extending throughout their length on one or both sides; start in segment 11.

Table 1. Comparison of Ice-Worms from Various Localities

	Malaspina	Mt. Rainier	Cliffe Glacier				Le Duc Glacier					
			A	D	E	O	P	A	B	G	H	SA
Spermathecae:—												
—no. of diverticula	(2) 3(4)	2	2	2	3	?	2	2	2	2	2	2
—gut openings separate (S) or common (C)	C	S	S	S	C	C	C	C	S	S	S	S
Penial apparatus:—												
—no. of atrial glands	8	5	5	5	4	?	4	4	5	?	?	3/4
—accessory glands (st = stalked; se = sessile)	st	se	se	se	se	se	se	se	se	se	se	se
—no. of multicellular penial glands	15	25	?	?	?	?	?	?	?	?	?	?
Length (mm)	12-20	12-18	14-18				16-20					
No. of segments	43-58	51-60	44-51				48-60					
Setae:—												
dorsal	2,3*	2,3-1,2	2-1,2				2,3-1,2					
ventral	3,4,5,6-4,5	2,3,4-2	3,4-2,3				3,4,5-2,3,4,5					
Segment of origin of dorsal blood vessel	12	13-14	13-14				13					

*No distinction made between pre- and postclitellar bundles

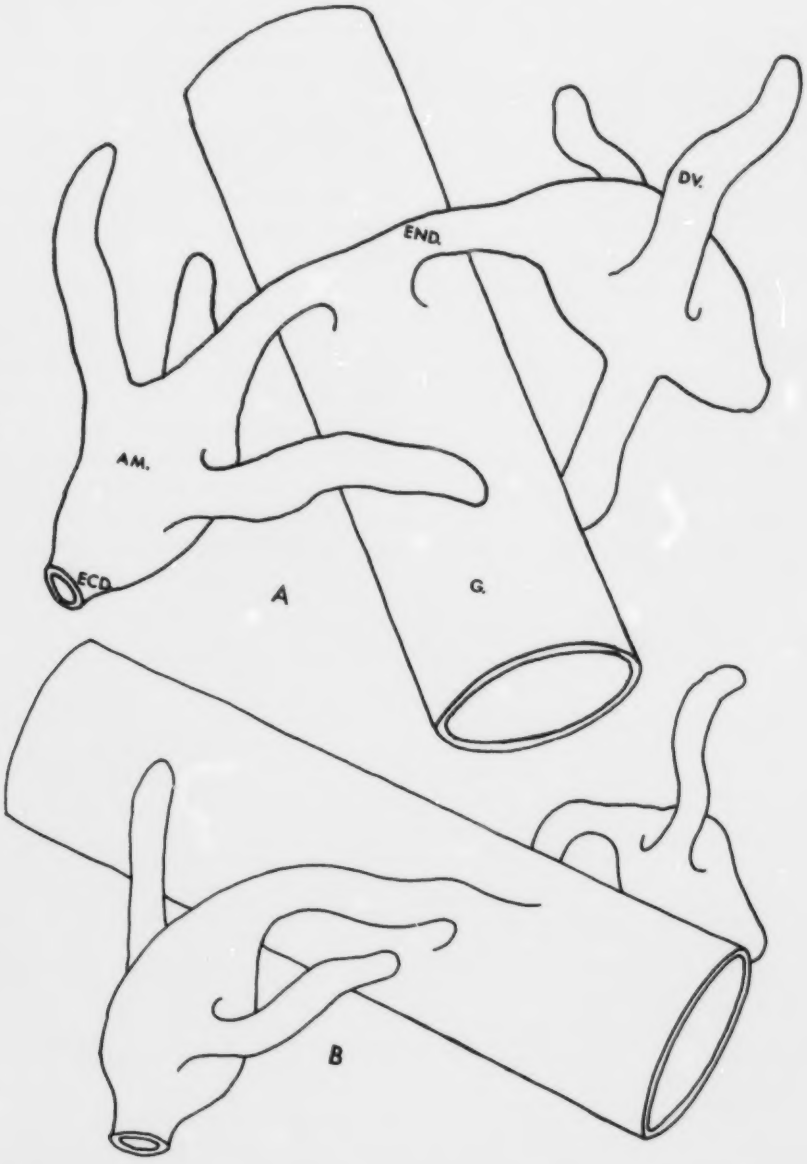

Figure 3 Spermathecae of *Mesenchytraeus solifugus*, (A) from the Malaspina Glacier; (B) from Mount Rainier. AM., ampulla: DV., diverticulum; ECD., ectal duct; END., ental duct; G., gut.

Egg sacs start in segment 12, usually paired, usually extending back for up to 10 segments, usually on both sides.

Penial apparatus with fusiform atrium into which open 3-8 atrial glands; the bulb bears numerous stalked or sessile accessory glands and contains numerous multicellular penial glands.

Spermathecae confined to segment 5; short ectal duct expanding only slightly into the ampulla; ampulla gives rise to two or three diverticula; the spermathecae of either side with a separate or common opening into the gut.

The specimens from the Malaspina Glacier differ sharply from those of Mt. Rainier, the Cliffe Glacier and the Le Duc Glacier in having a slightly higher number of stalked accessory glands (8 instead of 3-5).

Description and Comparison

The external appearance of an ice-worm is shown in Figure 2, p. 2.

Spermathecae

In the Enchytraeidae in general, the spermathecae, situated in the fifth segment and opening in the furrow between segment 4 and 5, are of great taxonomic significance. The genus *Mesenchytraeus* is no exception. Existing descriptions differ with respect to two features of *M. solifugus:* the number of diverticula and the connection of the spermatheca with the alimentary canal (*see* Fig. 3—DV., END.; Table 1).

Emery (1900) figured the spermathecae as having two diverticula on one side of the animal and three on the other. The spermathecae of each side united dorsally but were not connected with the gut. Moore (1899) noted three diverticula on all spermathecae; the organs united dorsally and had a common opening into the dorsal gut wall. Since both sets of specimens were taken from the Malaspina Glacier and since Emery admitted (1900, p. 230) that his specimens were immature, it is possible that Moore's description is the more valid one. Eisen's (1904) description of some Alaskan forms is in agreement with Moore, except that Eisen figured a small fourth diverticulum on the spermatheca of one side (p. 60). Welch described the Mt. Rainier forms as having always two diverticula on each spermatheca; the latter opened independently into the left and right sides of the gut.

The condition of the spermathecae in the Cliffe Glacier specimens is variable (Fig. 3; Table 1, p. 3). One (series E) is just like the Alaskan specimens; two more (series A and D) are comparable to the Mt. Rainier forms. The remainder (series O and P) are intermediate, having only two diverticula, but with a common opening into the gut. Of the Le Duc Glacier worms, all but one (series A) are the same as the Mt. Rainier forms.

Sperm Sacs and Egg Sacs

In the genus *Mesenchytraeus,* sperm and egg sacs are usually present and consist of backward extensions of the posterior septum of the segment in which the gonads occur (*see* Fig. 4, p. 6). Often, they bifurcate before terminating. Also, they frequently terminate a considerable number of segments behind their segment of origin (this being segment 11 for the sperm sac and 12 for the egg sac). The terminal segment is variable within a given species. The sperm duct is often found lying within the ovisac, which means, since it originates in segment 11, that it has to pierce the wall of the sperm sac or the septum 11/12.

Figure 4 A, B, shows the differences between the Malaspina and Mt. Rainier worms with respect to the sperm and

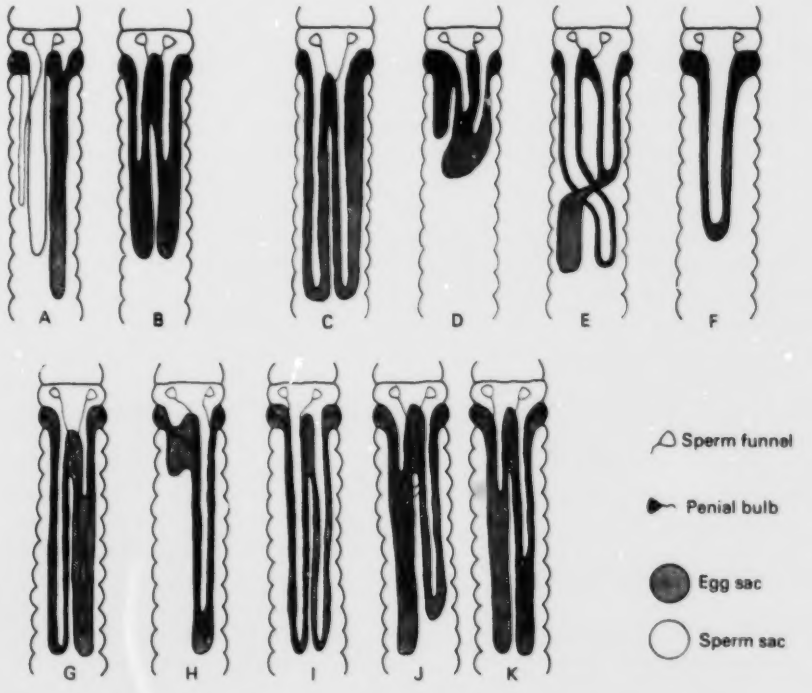

Figure 4 Sperm sacs and egg sacs of *Mesenchytraeus solifugus*. (A) from the Malaspina Glacier; (B) from Mount Rainier; (C-G) from the Le Duc Glacier; (H-K) from the Cliffe Glacier. In most cases, the terminal segments could not be determined so the terminal segment shown in the above diagrams is quite arbitrary. However, in K, the terminal segments shown are correct.

egg sacs. Fig. 4C-K, illustrates the variable anatomy of the British Columbia forms. The points of bifurcation and termination could not usually be determined accurately. The significance of these findings is discussed below.

The Penial Apparatus

The penis and associated glands are usually very elaborate in *Mesenchytraeus* spp., and were considered very important specific characters by Eisen (1904) and subsequent American authors. Moore (1899) described the penial apparatus of his specimens briefly, without figures, and used different terminology from that established later by Eisen. Eisen's (1904) figure, reproduced here (*see* Fig. 5, p. 7), is based on the ice-worms collected by the Harriman Alaska Expedition from the Muir and La Perouse Glaciers. According to Welch (1916), the penial apparatus of *M. solifugus rainierensis* differed from that of the species in having shorter accessory glands, fewer atrial glands (5 instead of 8) and more multicellular penial glands (25 instead of 15). Actually, the difference in the accessory glands appears to be more fundamental; those of the Alaskan specimens had long stalks, while those of the Mt. Rainier worms were sessile. Eisen (1904) defined ac-

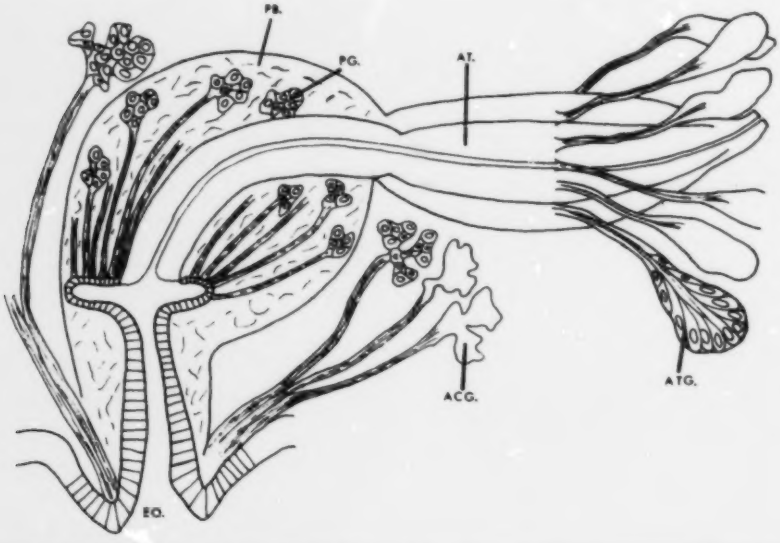

Figure 5 Eisen's (1904) diagram of penial bulb of *Mesenchytraeus solifugus*. ACG., accessory glands; AT., atrium; ATG., atrial glands; EO., ectal opening; PB., penial bulb; PG., penial glands.

cessory glands as glands opening around the penial bulb but not entering it. However, in the same publication, *Mesenchytraeus franciscanus* was figured with accessory glands entering the penial bulb (Eisen 1904, Pl. IV, fig. 4). To encompass this case, one might redefine accessory glands as associated with penial bulb but originating outside it. In any event, the boundaries of the bulb must be clear for the definition to be meaningful. Both Eisen (1904) and Welch (1916) imply or state in figure or text that the bulb is delimited by a membrane. However, Welch admitted, "The surrounding envelope is very delicate and it is difficult in some of the specimens to determine just how many of the glands at the edge of the bulb are to be classed as accessory" (Welch 1916, p. 114). In the same paragraph, he also commented on the similarity in structure between the accessory glands and the multicellular penial glands. (The bulb was said to contain both multicellular and unicellular glands interspersed with muscle fibres).

In the British Columbia forms, from both locations, it has proven impossible to separate accessory glands and multicellar penial glands for the very reasons outlined by Welch. The thin bounding membrane of the penial bulb is occasionally visible, but never where it is needed, i.e., in the areas of large aggregations of multicellular glands. I doubt if the number of penial glands can be determinated from serial sections. (Plate I—A to C, p. 8).

The British Columbia ice-worms usually had either four or five atrial glands on each atrium. Their numbers could be determined fairly reliably by counting the ducts where they entered the atrium (Plate I, D, p. 8).

Other points of comparison are summarized in Table 1, p. 3. No significant differences are revealed.

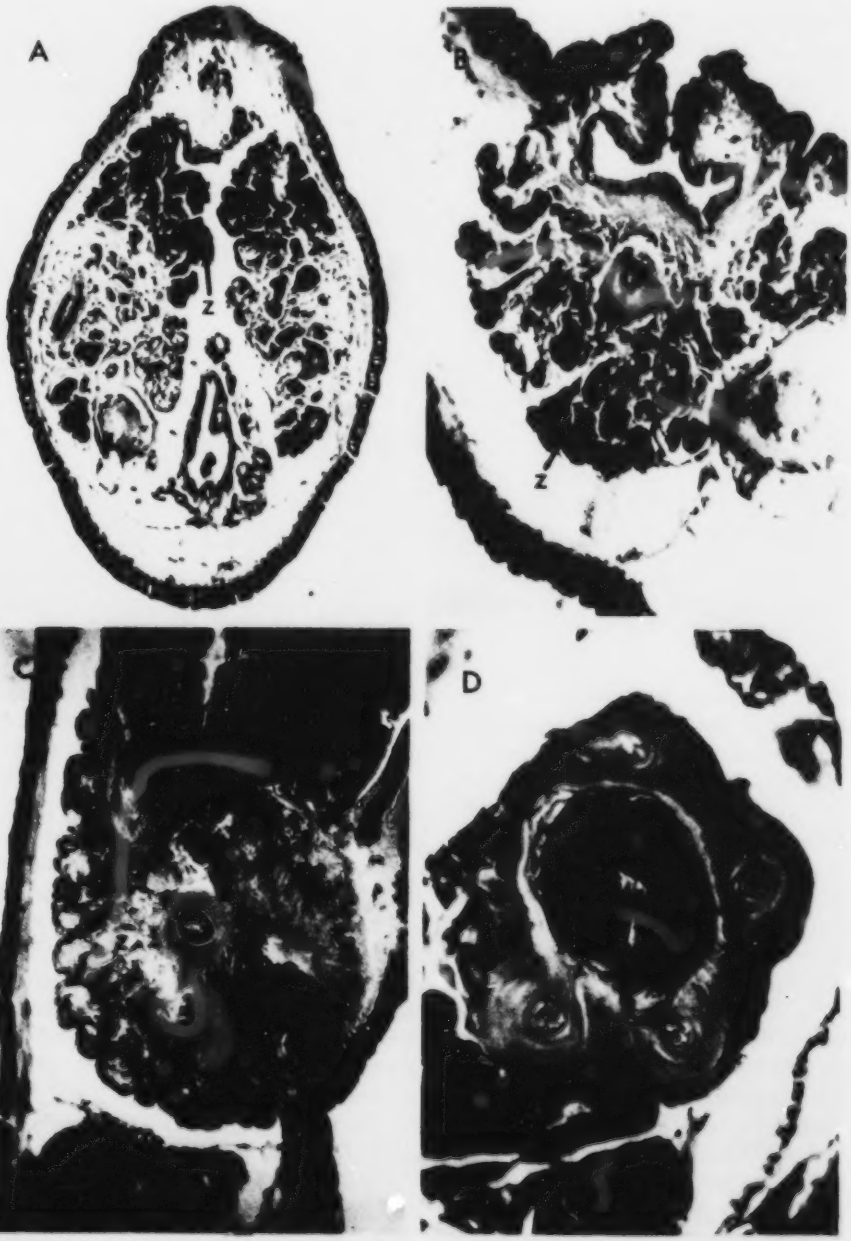

Plate I (A), T. S. ***Mesenchytraeus solifugus*** in region of penial bulbs. (B, C), sections through penial bulbs; (D), T. S. atrium and duct of atrial glands. Z, accessory and / or penial glands.

Discussion

In general, the marked variability of the British Columbia specimens contrasts with the condition of the previously described forms. In the case of the Alaskan specimens, perhaps we may doubt this apparent constancy, since only three worms were sectioned (Moore 1899, p. 128). Welch (1916, p. 105), however, stated, "The description is based on 27 sexually mature specimens. Forty-eight other specimens of uncertain sexual maturity were examined in the study of external characters". I have examined scarcely more specimens than Moore, and yet encountered a marked amount of variation.

Variation in the condition of the sperm and egg sacs may be not significant. It is possible that the backward extent of these sacs increases with the quantities of gametes since quite large worms, if they have no gametes, show no trace of sperm or egg sacs. In the Alaskan ice-worms, the sperm sac was absent on one side; however, since the ovisac on that side was full of eggs it may have thus prevented the intrusion of the sperm sac. Further confusion may result from the fact that, after a discharge of gametes, the thin-walled sacs appear to collapse and possibly degenerate, making their detection difficult or impossible. Also, if the testes sac is full of sperm, it will be pressed against the wall of the ovisac, and the walls of the two sacs may become indistinguishable thus giving the impression that there is no ovisac.

Variation in the number of spermathecal diverticula is not common in *Mesenchytraeus* or among the Enchytraeidae in general. In the European species, *M. flavus* (Levinsen), some individuals have a vestigial second diverticulum (Nielsen and Christensen 1959). However, this sort of variability in the British Columbia ice-worms, especially in those from Vancouver Island, would not be very surprising were it not for the constancy of the Mt. Rainier specimens. It will be noticed (*see* Table 1, p. 3) that, in this respect and in respect to the opening of the spermathecae into the gut, the Le Duc worms are very much closer to Welch's Mt. Rainier individuals than are those from Vancouver Island.

Apart from the above-mentioned difficulties in distinguishing accessory from penial glands, the penial apparatus of the British Columbia forms resembles that of the Mt. Rainier worms insofar as there are no long-stalked glands found in association with the penial bulbs. The two groups have similar numbers of atrial glands also.

It is evident that more data are needed, especially on the Alaskan ice-worms. However, some conclusions may be drawn from the information at hand regarding the status of the British Columbia forms described in this paper. The only crucial difference between populations lies in the stalked accessory glands of the Alaskan forms as against the sessile condition of those found in the more southern populations. Possibly, the difference in the numbers of these glands is also significant. All other characters are too variable to be of any value, including the condition of the spermathecae.

It seems appropriate, then, to place the British Columbia worms in the subspecies *Mesenchytraeus solifugus rainierensis* (Welch 1916), while pointing out that those from the Cliffe Glacier seem somewhat more different from the Le Duc and Mt. Rainier forms than these two last-named do from each other. This fact might be explained by the presence of the Coastal Trough (Strait of Georgia and Puget Sound) which separated the mainland and island populations at an early stage. (If this were the case, one would expect worms from Mt. Olympus

to resemble those from the Cliffe Glacier; unfortunately, no data are available on the Mt. Olympus ice-worms). However, if we are to explain differences between populations on the basis of geographical and glaciological factors, we must face the fact that the Le Duc Glacier is considerably nearer to the Malaspina Glacier than to Mt. Rainier and, moreover, it lies to the north of the Nass and Skeena Rivers, a region with few glaciers, and one which might be expected to form some sort of boundary in ice-worm population distribution. This difficulty cannot, at present, be surmounted.

On the basis of available evidence, it seems that the ice-worms from the Cliffe and Le Duc Glaciers—especially the latter—are more similar to those described from Mt. Rainier, Washington, than they are to those from the Malaspina Glacier, Alaska. However, the Cliffe Glacier worms exhibit marked variability in the number of spermathecal diverticula and in the manner in which the spermatheca connect with the gut, some of the specimens resembling the Alaskan worms in this respect. It is speculated that these differences between mainland and island forms may have been due to an early separation of the populations with the early retreat of the ice in the lowlands between them after the last glaciation.

Addendum

I recently received a paper (Goodman 1971) dealing with ice-worms from the Casement Glacier in the Alaska Panhandle. The paper contains some interesting ecological data and also descriptions of three mature worms. Those observations are briefly considered here since they became available too late for inclusion in the main body of this paper.

Salivary Glands

Goodman reports salivary glands in the Casement Glacier specimens. This is most surprising since salivary glands are not otherwise known in the genus *Mesenchytraeus*. It is possible that what Goodman describes are, in fact, septal glands.

Penial Apparatus

Goodman has the same doubts and difficulties as I did with regard to penial and accessory glands. "Owing to the extreme delicacy of the peritoneum surrounding the bulb, whether all, part or none of a lobate gland lies within its boundaries is a largely gratuitous distinction" (p. 17). He concludes that accessory glands are absent but the 13 multicellular penial glands on his Figure 2 could be interpreted as stalked accessory glands. Six atrial glands are present.

Spermathecae

There are two diverticula in Goodman's specimens and the ampulla have a common opening into the gut.

Sperm and Ovisacs

These are generally similar to the Mt. Rainier specimens.

In conclusion, it must be affirmed that the points of difference between the various populations relate to features which are difficult to determine accurately.

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